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MAPLE SIRUP

and other

MAPLE PRODUCTS

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Maple Sirup
and Other Maple Products

F. E. WINCH, JR. AND R. R. MORROW

GENERAL INFORMATION

Of the foods produced in New York, maple sugar, maple sirup, and the newer product maple cream are typically American. These foods, definitely luxuries, are attractive products from which the sugar "bush" or grove operator may obtain substantial cash return for labor and investment. They are made when other farm work is not pressing.

Maple sirup production in North America

Maple sirup and sugar are commercial crops from Maine to Minnesota and in adjacent areas of Canada, particularly Quebec; south to Iowa; east to Ohio, West Virginia and Maryland. More than two-thirds of the United States production comes from New York and New England. About 30 percent of the total United States production comes from New York.

In the United States, a record crop of 6,612,500 gallons of maple sirup was reported in 1860. Since then, production has dropped in most areas because of the decline in the price of white sugar which lowered the comparable price of maple sugar and sirup. The ten-year average production for the United States from 1943 to 1952 was 1,818,000 gallons. Many factors contributed to the decline of the industry during this period. The war brought ceiling prices, labor was short, weather conditions were unusually difficult, and production was limited. For 1955 the national production was 1,657,000 gallons of sirup and 246,000 pounds of sugar.

Canadian production has followed somewhat the same trend. In 1950 the production was 2,801,000 imperial gallons (5 quarts), in 1952 it was 3,254,000, and in 1954 it was 2,304,000.

Maple sirup production in New York

The leading sirup-producing counties in New York in the order of their 1950 census production reports are: St. Lawrence, Lewis,

Chautauqua, Wyoming, Cattaraugus, Allegany, Franklin, Delaware, Chenango, and Clinton. Since 1952 interest in maple production has increased. New bushes have been tapped, new producers have started in the business, and new marketing techniques have resulted in better farm income, with an annual crop valued in excess of $2,000,000.

Sugar maple trees are so numerous over most of New York State except on Long Island that many good stands are never tapped. Many former "bushes" fall to the lumberman's axe, but the sugar maple renews itself with such vigor that young stands are continually developing. Furthermore, many farmers do not tap their maples and others make maple products of lower grade than this luxury product deserves. This publication suggests ways New York producers may improve their product, *increase* the yield, *decrease* the cost, and consequently *receive a better income from the enterprise.*

The tree

The sweet sap or "sweet water" from which sirup and sugar is made is common to all the native maples, but hard, rock, or sugar maple, *Acer saccharum,* (figure 1) furnishes sweeter, more palatable sap for at least three-fourths of the commercial sirup and sugar produced. This vigorous and splendid tree is found in commercial timber quantities from the mountains of the Carolinas and Missouri north to the St. Lawrence valley of Canada. The tree seeds vigorously, is a strong and vigorous grower adapted to many soils, and is tolerant of shade during most of its life. For these reasons it maintains and renews itself for years against competition of other species. As a result of the aggressive characteristics of the species, there are many pure stands of sugar maple in New York.

The tree prefers a well-drained site, but may be found growing under nearly all conditions and on all soils except swamps and bare sand areas. It grows well on glacial till or rocky hillsides and benches. Climate, crown size, and vigor have more influence on the yield and quality of the sap than has soil.

Black maple, *Acer nigrum,* a form of sugar maple, is found in many parts of New York. It so

Figure 1. Sugar maple. Leaf, one-third natural size; fruit and twig, one-half natural size.

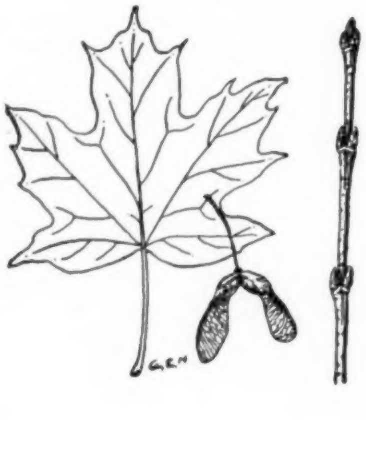


Figure 2. Red maple. Twig, one-half natural size; leaf and fruit, one-third natural size.

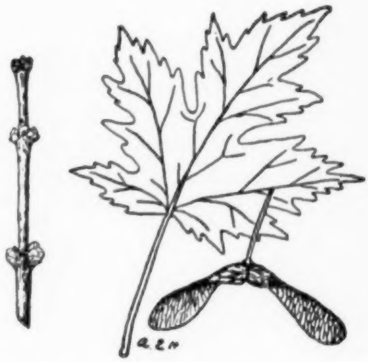


Figure 3. Silver maple. Twig, one-half natural size; leaf and fruit, one-third natural size.

closely resembles sugar maple that it is usually reported as that species.

Red maple, *Acer rubrum*, (figure 2) ranges from Canada south to Florida and Texas. The name refers to the color of the prominent winter buds and flowers, and to the leaf in autumn. The wood is also lightly tinged with reddish chocolate color. The sap generally is much lower in sugar content than that of sugar maple.

Silver maple, *Acer saccharinum*, (figure 3) is usually called *soft maple* when growing in the woods; when used in parks and in ornamental work, it is called *silver maple* because of the white underside of the leaf. The tree is weak and short lived. The sap is similar to that of red maple.

Research in many areas has shown that red and silver maple produce only two-thirds as much as does sugar maple. This sap is only two-thirds as sweet. Many expert sugar tasters can tell when sirup or sugar is made from soft maples because of "pungent," slightly bitter after-taste of these products.

Both red and silver maple are found in many sugar bushes in association with sugar maple. Since the sap of both of these trees is inferior in sugar content to that of the sugar maple and the quantity is less, it is advisable to remove these trees from the bush in favor of the sugar maple.

Where the maple tree gets its sugar

Plants differ from animals in that plants make their own food. A tree, which is a large plant, obtains large

quantities of water from the soil through the root system. The necessary soil nutrients are mixed in the water. From the air a gas, carbon dioxide, diffuses into the leaves through minute openings. Chlorophyll is the substance in the leaf cells which makes the leaf green. Each leaf is a factory where water and carbon dioxide are chemically changed into sugar. This is possible only in green leaves containing chlorophyll and requires the energy of sunlight.

A large leaf area exposed to sunlight creates a large amount of sugar. This means, however, that more water is evaporated—as much as 100 tons of water in one year from a large tree—and a good soil with an adequate supply of water is necessary. The sugar made by the leaves is used for tree growth. A little of the newly made sugar is used immediately in the leaf, but most moves out to the branches, trunk, and roots. Here part of the sugar is used in the growing points of the branches and roots, for seed production, and in the cambium for diameter growth of the trunk. Much of the sugar, however, is changed to starch to be stored for use in tree growth in the following spring. Obviously, only a small proportion of the sugar can be taken without noticeable change in the tree's general health and vigor. Probably less than 10 percent of the sugar is normally taken by tapping.

With the coming of cold weather, the starch, which is not soluble in water and cannot move in the sap stream as can sugar, is gradually changed back to sugar. The sugar reaches its highest concentration in late winter and early spring, coinciding with the sap season. Present also are certain other organic compounds that contribute to the characteristic maple flavor. In many years, the late-season sap flow decreases notably in sugar content, corresponding with the coming of warm weather and the beginning of tree-growth activity.

Relation of sap to sirup

The length of the boiling period is especially important, for the boiling process develops the characteristic maple flavor and color of the sirup. Good clear sap boiled quickly makes light-colored delicately flavored, high-grade maple sirup. The same sap boiled over a long period of time makes dark-colored sirup of lower quality. Long boiling of sap at high sugar concentrations (more than 40 percent) causes a browning, or caramelization, of the sirup. Often this caramel flavor predominates over the true maple flavor. Hence it is important to have an efficient evaporating system, both as to fuel economy and speed of evaporation.

The sugar content of the sap influences the grade of sirup, for sweet sap can be boiled down much more quickly than can sap with a higher proportion of water. The more sugar in the sap, the more

and better sirup can be made with the same amount of sap, labor, and equipment. The sugar content of the sap varies from tree to tree and also from day to day and from season to season. A sap hydrometer (preferably a large model that can be read to 0.1 percent) placed in stirred sap gives the sugar percentage after the reading is corrected for temperature. The sirup yield for sap of varying sugar concentrations can be determined from this formula:

$$\text{Gallons of sap per gallon of sirup} = \frac{86}{\text{sap sugar percent}}$$

Thus 2 percent sap requires 43 gallons of sap for 1 gallon of standard density sirup, while 3 percent sap requires only 29 gallons. Average sugar concentration of sugar-bush sap is about 2 percent, and average sap flow is from 10 to 12 gallons per bucket. Therefore, each bucket yields approximately 1 quart of sirup in an average year. In 1944, the sap was unusually sweet and sap flow was above average so that many producers made more than 2 quarts per bucket. In 1953, the reverse was true and many producers made less than 1 pint of sirup per bucket hung. Efficient boiling methods can, however, largely counteract the effects of low sugar concentration.

Good-quality sirup depends also on clean sap, relatively free of microorganisms. Theoretically it is possible to make high-grade sirup throughout the season if the microorganism count can be kept low. Several producers have helped their quality production by washing spiles and buckets during the season.

Normally, there is little bacterial activity in the cool, early season. With the warm spells of late season, however, the sap spoils quickly unless gathered promptly and boiled down the same day. Microbial action helps to break down the normal sap sugar, called *sucrose*, into invert sugar. Sirup made from sap with much invert sugar may be dark in color, low in grade, poor in flavor, and cannot be made into maple cream. Microbial activity, not buddy sap, is the principal reason why low-grade sirup is made by most producers late in the season. The best remedy is clean equipment and both fast handling and fast evaporation of the sap before the bacteria can take full effect. Thus a high-grade sirup depends on fast boiling, high sugar content of the sap, and a low microorganism count.

THE SUGAR BUSH

The ideal sugar bush

The ideal sugar bush perhaps does not exist. Why examine it then? Only by understanding the ideal sugar bush can one correct the management of the existing sugar bush that he taps each year.

Research has pointed out the following helpful facts:

1. Often sugar concentration in the sap of neighboring trees and neighboring bushes differs considerably. Probably much of this is caused by heredity; that is, some trees are inherently sweeter than others. The size of the tree crown (part of tree having leaves) also affects sugar concentration, which is usually higher in trees with wide crowns and also in trees with deep crowns coming near the ground. Trees in the open have higher sugar concentration regardless of crown size. These facts are not surprising since the sugar is made in the leaves and depends on both the number of leaves and the amount of light available (figure 4).

2. Likewise there is considerable difference in the amount of sap per bucket obtained from trees of the same or neighboring sugar bushes. This difference is due also to heredity, to size of tree crown, and to openness. In addition, elevation, exposure to winds, and direction of slope influence the amount of sap. Diameter of the tree also influences sap flow.

3. Since sugar concentration depends on heredity and size and openness of the crown, characteristics that change little from year to year, it is expected that a tree that is sweet one year will be sweet in other years. While sugar concentration may change from day to day and year to year, a sweet tree does tend to remain sweet in comparison with its neighbors. The same is true with sap flow, which may vary more with weather conditions or location of tap holes.

4. As with sugar percentage and sap flow, sirup production per

Figure 4. An ideal sugar tree. A wide, deep crown, open to full sunlight results in high sugar production.

bucket increases with the size and openness of the tree crown. A study of 30 farms in Lewis County showed that sirup production per bucket was approximately proportional to the average diameter of the tree crowns. Under average tapping conditions, each tap hole yields approximately from 0.10 to 0.12 gallon of sirup for every 10 feet of average crown diameter.

5. Total sirup production per acre is about the same regardless of tree size, provided each acre has the same proportional coverage of tapped sugar maples (table 1).

6. Increased sirup production per bucket in trees with large crowns lowers production costs, mainly because of the increased sugar percentage which means more and better quality sirup from the same amount of labor or equipment used (table 2).

The ideal sugar bush then is created by the development of single large-crowned trees rather than aiming for a certain number of trees or production per acre. The ideal sugar bush contains trees with heavy limbs, the direct opposite of trees wanted for timber

Table 1. Relation of Sirup Production to Tree Crowns
(Typical average figures—assumes heavy stocking with sugar maple only)

Crown diameter	18 feet	25 feet	32 feet	40 feet
Crown depth	20 feet	35 feet	45 feet	55 feet
Diameter breast height	13 inches	19 inches	24 inches	28 inches
Sugar percentage	2.1	2.2	2.5	2.8
Gallons of sap per bucket	9	11	13	15
Gallons of sirup per bucket	0.22	0.28	0.38	0.49
Number of trees per acre	150	75	40	25
Number of buckets per acre	150	120	100	80
Gallons of sirup per acre	33	34	38	39

Table 2. Relation of Production Cost to Tree Crowns
(Typical figures)

Average crown diameter	18 feet		40 feet
Number of buckets and spiles	150	(nearly double tapping equipment and labor)	80 80
Sugar percentage	2.1	(33 percent more gathering trips) (33 percent more fuel) (33 percent longer boiling time) (less fancy sirup)	2.8
Cost per gallon	$3.50		$2.50
Selling price per gallon	$4.50		$4.75
Profit per gallon	$1.00		$2.25

production. *The price of maple logs is too low to compensate for the inefficient sirup production of good lumber trees as compared with limby, open trees* where the climate is well-suited to good sap flows.

The ideal sugar bush involves much planning for its development, beginning with seedling and sapling development. Location of roads and sap house must be considered. Good soil and exposure are necessary for maximum production.

Trees in the final stage of the ideal sugar bush are about the same age, about 40 feet apart, and have crowns that reach nearly to the ground. There are from 25 to 30 trees per acre, from 80 to 100 buckets per acre, and an average annual production of 0.4 to 0.5 gallon of sirup per bucket or 40 gallons per acre per year. That such production is possible was proved in 1954, a barely better-than-average year, when several producers made more than one-half (0.5) gallon of sirup (twice state average) per bucket from roadside trees. In 1955 one of these producers made 2600 gallons of sirup from 3300 tap holes. Each tap hole averaged 25 gallons of 2.7 percent sap.

Location and number of trees

It is an advantage to have the sugar bush close to the farmstead so that the work fits in with other farm operations. Sugar bushes far removed can seldom be operated economically unless there is some special provision for travel or housing facilities so that the men may spend all their time in the production of sirup or sugar. These greater overhead charges require many trees in the bush and a large, well-equipped, evaporating plant. The ordinary producer, however, wants to do his sugaring in a nearby bush, and uses for lumber the more inaccessible woods which are not necessarily entered each year.

The direction of slope and the elevation of the sugar bush are important considerations. In some years yields from the hilltop sugar bushes exceed those from trees in the valley; perhaps more often the reverse is true. Possibly sugar bushes need to receive as much sunlight as possible to lengthen the daily sap-flow period early in the season. This requires slopes that face from southeast to southwest at medium elevations. Furthermore, a bush should not be exposed to constant cold winds, so sugar bushes at high elevations should not face north or northwest. A wind mantle or windbreak around the edges of nearly level bushes helps to protect such areas. It may be advantageous to operate two or three small sugar bushes that flow at somewhat different times raher than one large sugar bush.

In normal years, a single tap hole produces 1 quart or more of sirup. The ordinary sugar bush from which the operator expects to get considerable financial returns should be capable of carrying at

least 500 buckets. Operations of 1000 to 1500 buckets are more efficient largely because of savings in time and fuel in the larger evaporators and a relatively lower cost for sap house and evaporator. A small sugar bush of large-crowned open-grown trees may be as profitable as a much larger sugar bush of woods trees, particularly if roadside trees are used.

Many sugar bushes have a mixture of other trees. Sugar bushes with fewer than 25 buckets per acre seldom show a profit. Thus, in developing a sugar bush one must think of the possible yield to the acre as well as the yield of each tree.

The forest floor—grazing

The forest floor is of great importance in the maintenance of a good sugar bush, for beneath it are the roots that support the trees and gather moisture. Maple sap is so largely water that a heavy flow is dependent upon a soil well supplied with available moisture. The leaves and humus of a good forest floor help to hold and store large quantities of rain water. This is characteristic of natural forest soils (figure 5).

Important also is the depth of the soil, for this largely determines how tall and how vigorously the trees will grow. Shallow soil may

Figure 5. A good forest floor. No grazing has been allowed and the leaves and humus act as a sponge to hold water.

directly decrease sap flow by limiting the root system and available water, especially when the upper soil is frozen. The most vigorous sugar bushes are on good farm soil, but where trees were often left because the land was sharply rolling or hummocky. Such soil has at least 2 or 3 feet of well-drained and well-aerated but moist and rich soil above the subsoil. An abundance of earthworms, which mix the leaves with the soil so that the ground is practically bare before each year's leaf fall, is an indication of a good sugar-bush soil.

Should the sugar bush be grazed? Unquestionably, continued heavy grazing by livestock hastens the death of the sugar bush—first the forest floor and then the trees themselves are destroyed. In the process, the compacted soil holds less water and dead branches and stagheads appear in the sugar trees. These reduce the tree crown, the source of the sugar and, along with less moisture in the soil, cause decreased production long before the final death of the stand. A five-year record of two adjoining sugar bushes in Ohio, one grazed and the other ungrazed, showed 30 percent less sirup from the grazed sugar bush, or about 6 gallons less, per acre each year. This was blamed on rot in the tree crowns and more wind movement due to lack of undergrowth. Wind removed some of the leaf litter and snow which allowed the soil to freeze so deep that sap water was less plentiful.

Some producers point to good sirup-production records from large-crowned trees in open, heavily grazed stands. This sirup production is due to crown size, not grazing, and it is better to obtain large crowns by proper thinning with the axe and chain saw than by grazing livestock.

Heavy grazing is harmful, but is there a place for light, controlled grazing? Recent experiments in central New York indicate that very light grazing has little overall influence on sap flow. This was where the cattle had good pasture and probably went into the adjoining sugar bush only occasionally for shade. A warm wind sometimes caused this grazed bush to flow before the adjacent ungrazed bush since there was little ground cover. On the other hand, the ungrazed bush sometimes continued to flow during a cold wind after the grazed bush had stopped. The total production of sirup from each sugar bush after four years was about equal. It appears, however, that sugar bushes exposed to cold north and northwest winds should not be grazed.

Even very light grazing eliminates the young maple seedlings and saplings necessary for continuing the life of a sugar bush where all the trees are of different ages. Where, however, the older trees are nearly the same age and will be cut at about the same time, it is easier to obtain reproduction after light grazing. Sugar maple seed is

plentiful, and complete exclusion of livestock for ten to twenty years before final cutting of the old bush allows a good new maple stand to be established where the forest floor has remained in good condition. If any grazing is allowed, this exclusion of grazing before final cutting must be part of a good sugar-bush management plan.

Perhaps the only good argument for light grazing is to eliminate the undergrowth which hinders sap collection. On the other hand this can also be done by cutting lanes from the roadways to the sugar trees. New brush-killer chemicals, such as 2, 4-D or 2, 4, 5-T, help to prevent regrowth and offer a cheap means of controlling the undergrowth in lanes.

Perhaps the best argument against even light grazing is the low-quality forage in the woods. Milk production is often reduced, and sometimes off-flavor milk results from grazing on certain plants. Certainly it is poor practice to let cattle in the sugar bush when proper pasture improvement can create far more and better forage for milk and meat production.

Establishing a sugar bush naturally

Leaders in the maple industry believe that the greatest problem of the industry is the ever-decreasing maple production. Lowered production means temporary high prices which lead to lost customers and use of substitutes. This is usually followed by a further loss of market and low prices. The number of trees tapped in the United States has declined 43 percent in the past seventeen years. Much of this decline has been due to deterioration of old sugar bushes, high labor costs, relatively higher prices for maple logs and, lack of capital for purchase of equipment. Every sirup-producing family, particularly those with children who will continue the business, have a stake in increasing sirup production in the future. Establishment and development of new efficient sugar bushes is the most practical way to do this.

Many sugar bushes are the remnants of original forests and are used to produce sugar because of the number of old maples present. These sugar bushes are often old, neglected, heavily grazed, and affected by butt rot, stagheadedness, sugar maple borer, forest tent caterpillar, or other insects. Other sugar bushes of tall, straight trees have gone before the lumberman's axe.

Fortunately, it is easy to establish a new sugar bush in such places, for the sugar maple is a prolific seeder. Thousands of maple seedlings become established on the open fields. It is only necessary to exclude livestock from the area and to reduce overhead shade. The old trees that have no lumber or firewood value may be poisoned or girdled to allow more light to reach the young seedlings and saplings.

Establishing a sugar bush by planting

The wide distribution of sugar maple throughout the State and the readiness with which seedlings develop under natural conditions has usually made planting unnecessary. A few planted sugar bushes have been yielding sap for decades. The future, however, may be different. When it is learned how to develop young maple plants from high-yielding parents, the sugar orchard will come into its own.

Planters of maple plantations should aim at a 40-by-40-foot spacing (figure 6). Trees should probably be planted at a spacing of 10 by 10 feet, or possibly as wide as 20 by 20 feet, to allow for some loss and to give a choice as to which trees would be best for the final sugar trees. It is usually desirable to plant other trees, preferably those that could be removed early for Christmas trees, in the open spaces. The field should be plowed and harrowed before planting, and some weeding around the young maple may be necessary for two or three years. The young plantation may need protection from animal pests, depending on the locality. As already emphasized, a plantation should be established only on moist, deep, rich soil.

Developing the sugar bush

Sugar maple, a tree that can stand shading, needs ample light for good growth. When vigorous trees are given room to grow on good soils, it is not uncommon to be able to tap in thirty years (when the tree is 10 inches in diameter at breast height). In unthinned stands, as much as seventy-five years may be required before the trees are ready to be tapped.

To develop the deep and wide tree crowns required for the ideal sugar bush, trees must be thinned to favor the better ones. Thinning should start when the trees are only saplings and be continued through much of the lifetime of the tree. Theoretically this is a good practice, for pure sugar-maple bushes produce from 15 to 45 gallons of maple sirup per acre which requires from 1 to 2 cords of wood for boiling. This is just the amount of wood grown each year on the good soils. In practice, however, most of the thinning required in a sugar bush should be done before the trees reach tappable size. Therefore an ideal sugar bush would be blocked into perhaps five equal areas, with each successive block from 20 to 30 years older and further along in development.

It is unfortunate that in most sugar bushes all trees are nearly the same age because of past cutting practices. The best plan here would be to divide the young sugar bush in need of thinning into five equal blocks and to confine each year's work to one block. After all five blocks had been thinned in a five-year period, the first block would be ready for more attention.

Figure 6. A 51-year-old sugar bush planted with eight-foot whips in 1896. Spacing 40 by 40 feet.

Long-range planning calls for the final cut in each block to be made at different times so that succeeding sugar bushes would not all be the same age.

The *first thinning* should be made *when saplings are from 10 to 12 feet tall* and only 1 inch in diameter. The best developed trees with the largest crowns should be selected at distances about 10 feet apart. They should be sound and free of forks. Most of the remaining competing trees should be cut or lopped with either a hatchet, light axe, or machete. Three men can cut back trees in this manner at the rate of an acre a day. Under good growing conditions, the crowns will touch again in five to eight years, indicating that a new thinning is needed. This thinning is continued until the trees have developed deep, wide crowns and are spaced from 35 to 40 feet apart. Later thinnings, of course, are not so severe as the first thinning and will yield wood for boiling sap. While the saplings are released from competition on all sides in the first thinning, later thinnings would ordinarily remove trees on only two sides or even one side. The branches of neighboring trees must never be allowed to come together for long, because the shading effect would cause the lower branches to die and fall off.

If thinning has been delayed until the trees are from 4 to 8 inches

Figure 7. Thinning in young stand to develop future sugar trees while obtaining the fuel for the spring boiling.

in diameter, much of the tree crown would already be lost. Successive thinning commencing at this stage, however, develops wide crowns with fair depth, especially if the tree continues to grow in height (figure 7). About the best to be expected from thinning trees from 8 to 15 inches in diameter is a wider, but not deeper, crown. If these trees are not thinned, however, the crowns become less deep through shading and the lower branches die. It goes without saying that other trees, such as beech and hemlock, should be removed first (figure 8).

In general, larger and older trees are less vigorous and should be thinned lightly. Heavy thinning in mature stands sometimes influences the remaining trees adversely. Little response to thinning can be expected in old trees, middle-age trees with small crowns, or trees growing under poor soil conditions.

A young maple bush that has grown so that about 24 feet of the trunk is clear of branches before the first thinning can be thinned for the production of saw logs as well as for sirup. Twenty-four feet is needed for a saw log because usually the lower 4 to 8 feet of tapped trees are not used by sawmillers; this leaves a 16-foot log. Older stands can be thinned to have two

logs (40 feet clear length), yet have a wide crown for sirup production. This procedure eliminates the cost of early, heavy thinning when the wood is not used for fuel in the evaporator.

In selecting trees to favor in a sugar bush where tapping has al-

Figure 8. Second-growth maple badly in need of thinning. Crown development will be limited since thinning has been delayed too long.

ready been done, the sap production and sugar percentage (measured with a sap hydrometer) should be considered as well as tree condition and crown size. While the trees with the largest crowns are usually the best producers, there are numerous exceptions.

For the producer who does not use wood for fuel to boil the sap, or has no market for pulpwood, fuelwood, or wood chips, the use of chemicals is an inexpensive way to thin his sugar bush. Most trees less than 4 inches in diameter are killed by basal sprays of 2,4,5-T in any season of the year. Ash and basswood are notable exceptions. For larger trees it is cheaper to pour the chemical into a frill of axe cuts around the tree.[1] Liquid sodium arsenite is much more dangerous to apply. The manufacturer's instructions should be read carefully before using any chemicals. One should avoid spilling chemicals, especially arsenicals; they may damage roots of desired trees.

Natural enemies of sugar maple

Sugar maple has few enemies considering its abundance in the forest and its presence on varying sites in the State. This is well borne out by the presence of large trees more than 200 years old that have been tapped by axe gashes, hand augurs, breast drills, and machines. Two insects, however, bear consideration—the forest tent caterpillar and the sugar maple borer.

The forest tent caterpillar

The forest tent caterpillar is present yearly in small numbers in nearly all forest stands and in such numbers causes little damage and hence is overlooked. Occasionally, its numbers are of epidemic proportions as in sections of New York in 1954 and 1955. Under these conditions the insects heavily defoliate the sugar maple—a preferred host. Such defoliations reduce the growth and vigor of the tree and cause a drop in sweetness of the sap. If defoliation is severe three years in succession, other insects attack the weakened trees and they die.

Control is essential in such valuable properties as sugar bushes. Aerial spraying as the egg clusters start to hatch reduces the population to numbers that natural enemies and parasites can control. Aerial spraying in Lewis, Jefferson, and St. Lawrence Counties cost from 50 cents to 1.00 an acre. Considering the value of the crop this is reasonable. In unsprayed adjacent areas sap production was reduced from 50 to 70 percent and quality was much lower. Outbreaks of the forest tent caterpillar should be controlled during the first year of their epidemic.

[1] Mimeograph leaflet 6 *Chemipeeling*, may be obtained by writing to Extension Forester, College of Agriculture, Ithaca, New York.

The sugar maple borer

The sugar maple borer is present in many maple stands in small numbers. Its work is easily noticeable. On exposed trunks there are dead areas where the bark has fallen off showing a small channel cut into the wood. If this channel completely circles the main stem of the tree, the crown dies. This insect prefers sunny warm trunks of the sugar maple, consequently it follows outbreaks of the forest tent caterpillar or heavy cutting. Control, therefore, is simply to prevent the rapid opening of the stand by frequent, light cuts and to maintain a vigorous crown on the desired trees.

Effect of tapping upon the tree

A maple tree that has been properly tapped is not seriously injured. The small amount of sugar taken is usually less than 10 percent of the tree's annual production. A hole made with a $\frac{7}{16}$-inch bit heals in two to three years if the trees are fairly vigorous. Large-crowned, fast-growing trees sometimes heal in one year. Plugging the tap hole is unnecessary and may delay healing. Large bits (as large as ¾ inch) are not recommended because they make wounds that take much longer to heal and are subject to decay. Such healed-over holes ruin the "butt cut" for lumber production.

A tap hole affects adjacent wood. The sapwood dries out and is killed in a strip equal to the depth of the hole and a little wider than its diameter. The dead wood normally extends 1 to 2 feet above the hole and usually a little less below the hole (figure 9). This dead area cannot be tapped until new wood

Figure 9. Longitudinal view of dead wood (dark streaks) made by tap holes.

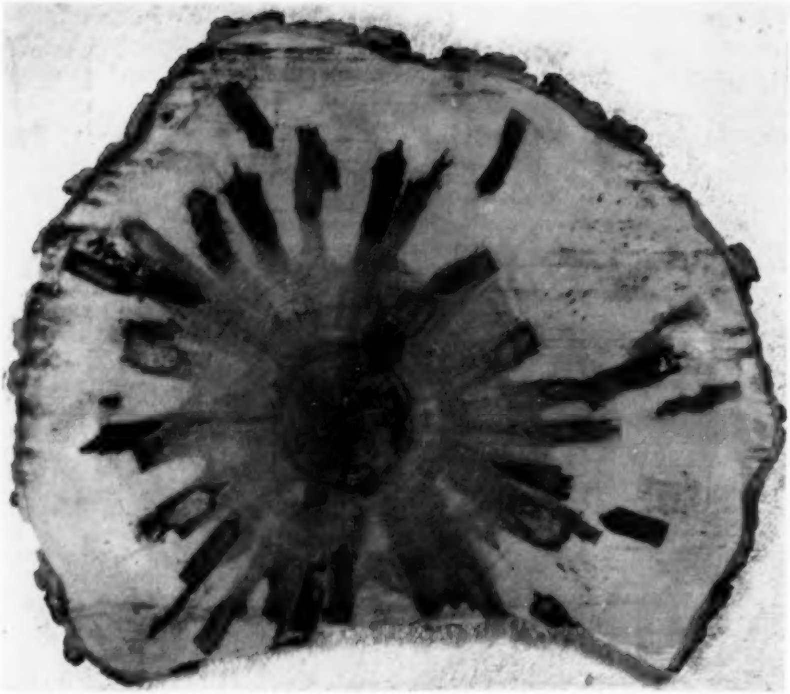


Figure 10. Cross-section view of dead wood caused by tap holes. Excessive tapping must be avoided since new wood has to grow over the old wounds before the tree can again be tapped in that region.

grows over it (figure 10). For this reason, *the practice of having more than one spile a bucket is strongly discouraged.* Likewise the practice of tapping a fresh hole to renew sap flow after a period of warm weather is discouraged. Reaming out old holes in mid-season is preferable to boring new ones, though this has not always proven to be economical.

Size of trees and number of buckets

Trees less than 9 to 10 inches in diameter at breast height are not worth tapping. As trees increase in diameter more buckets may be hung without serious injury to the tree. The following practice is recommended as giving the greatest yield of sap from year to year without affecting the health and vigor of the trees.

Tree diameter at breast height	*Number of buckets to be hung*
10 to 15 inches	1
16 to 20 inches	2
21 to 25 inches	3
26 and over	4

Tapping and hanging buckets in excess of the numbers indicated does not increase sap yield, but does increase the amount of dead sap wood in the tree. *The practice of tapping two holes close together and gathering the sap in one bucket seriously affects the vigor of the tree and reduces its value.* Instead of tapping at the suggested rates given above many operators are more conservative and hang fewer buckets per tree *especially on slow-growing woods trees.*

Tapping and bucket hanging

Maple sap flows during thaws from late autumn on. Sap flow prior to January, however, is usually in small amounts and low in sugar content. The best sugar-making months are usually March and April until the buds begin to swell, but good runs can often be obtained in February, as has been general during the past few years.

Tapping should be done early enough to catch the first real run of sap for the following reasons:

1. Yearly costs of sirup making are influenced most by the total amount of sirup made for each bucket hung. Catching early runs increases the yearly total at little extra cost.

2. The best-quality sap flows early, resulting in more high-grade sirup. At this time the sugar content is higher than in late season; microbial action is very low; the sap itself undergoes chemical changes as the season progresses and sugar sand is often less than in late season.

3. Early tapping may sometimes reduce late-season sap flows, but more and better quality sap in early season more than offsets this.

To catch the first good run, a representative test tree in each sugar bush should be tapped early in the season. Start of the sap flow varies with size of tree crowns, openness, elevation, and exposure. Large-crowned trees in the open at low elevations often flow first. All equipment should be ready ahead of time and special attention paid to daily and five-day weather forecasts as the season approaches.

Tap holes should be made about 6 inches away from the nearest visible tapping scar. With a 3/8- or 7/16-inch bit or wood drill, a hole is bored slightly upward to allow for drainage. The spile is inserted at once and tapped lightly. If driven too hard, the bark may split and a leaky tap hole results. Tapping in frozen wood is easier than tapping on warm days. At the time of the first sap gathering, tap hole leaks may be stopped by lightly tapping the leaky spile again.

Because of the dead wood made by each tap hole, the trees should be tapped on all sides and at different levels from 2 to 5 feet up

and down the trunk. Concentrated tapping on the south side year after year makes dead wood faster than the tree can grow new wood over it. The tap flow is about the same on each side of the tree, but north taps start to flow later in the spring and continue to flow after south taps dry up. For this reason, it may be wise to tap the north sides of all trees in the same year, or if the so-called "first run" is missed. If tapping has been delayed until after the season is well started, it is wise to tap on the north side to get a bigger flow.

Tap holes are made to a depth of 2 to 4 inches. There is a little more sap flow from the deeper tap holes, but more dead wood is made. For trees tapped year after year, only the most vigorous fast growers should be tapped to a depth of 4 inches. The producer who bores tap holes by hand will doubtless soon favor a tapping depth of only 2 inches. In old trees with little sapwood, care must be taken to prevent boring into the brown heartwood. Heartwood yields no sap, is very susceptible to decay and may darken the sap.

Gathering the sap

Microorganisms start growing in maple sap at nearly freezing temperatures. Bacterial growth is fairly limited at temperatures below 40° F. for a short time, but warmer temperatures increase the growth many fold. Therefore, every bucket should ideally be emptied once a day, and perhaps more often in the warm days late in the season. Early in the season it is advisable to empty the buckets in the evening near the end of the daily flow to prevent freezing damage to buckets during the night.

Buckets are emptied, often by spinning on the spile, into gathering pails which are carried to the gathering tank. A fine-meshed strainer or cloth over the mouth of the gathering tank keeps out leaves, twigs, and dirt. All sap should be hauled to a storage tank, outside the sap house, strained, and put through the evaporator as rapidly as possible. Efficiency should be stressed as 40 percent of the labor of sirup making is charged to gatherings (table 3).

A recent development is the use of rayon filter paper to filter the sap as it comes from the gathering tank to the storage tank. This removes very small bits of debris which may wash in from the bark with rain water. It does not remove the material known as "sugar sand." Some producers report greatly increased amounts of higher grade sirup with this pre-boiling filter.

Ice that forms in a bucket of sap is usually thrown away, for it has a much lower sugar content than the sap. Some producers, however, keep the ice to hold down temperatures and prevent bacteria growth when they cannot collect sap every day.

The sap flow is never continu-

ous, but is broken into several runs during the season. Between runs it is recommended that the storage tank be washed. Several producers have made a practice of washing metal buckets at the time the sap shows bacterial action in order to raise the sirup grade. Any good dairy bacteriacide may be used.

Sour sap—buddy sap

The sap at the beginning of the season is water white, clear, and transparent. It has a sweet taste and practically no odor. When sap is running strong, the danger of microbial action and souring is not great; but when warm weather comes and the flow is intermittent,

Table 3. Costs and Returns from 57 New York Farms, 1955*

Items	Averages			
	Northern New York	Central New York	Southwestern New York	New York State
Number buckets hung	1235	1728	1454	
Number gallons produced	272	611	524	
Quarts per bucket	0.88	1.41	1.44	1.24
Price received per gallon				$4.77
Production costs per gallon				
Fixed costs				
Interest	$0.35	$0.28	$0.24	$0.29
Depreciation	0.39	0.32	0.27	0.33
Use of sugar bush	0.46	0.33	0.26	0.35
Insurance	0.01	0.02	0.01	0.02
Total fixed costs	$1.21	$0.95	$0.78	$ .99
Man labor	$1.10	1.07	1.03	1.07
Horse, tractor, truck	0.21	0.18	0.17	0.19
Fuel	0.40	0.39	0.32	0.38
Repairs	0.07	0.06	0.01	0.05
Miscellaneous	0.01			0.01
Marketing	0.23	0.38	0.24	0.32
Total cost per gallon	$3.23	$3.03	$2.55	$3.01
Net gain per gallon				$1.76
Return per hour of labor				$2.62
Minutes spent per gallon				
Tapping and hanging buckets	9	6	8	7
Gathering sap	28	26	23	26
Boiling	19	18	19	19
Marketing	2	2	2	2
Clean-up (pre- and post-season)	9	6	9	7
Total labor (minutes)	67	58	61	61

* Summarized from *Costs and Returns in Producing and Marketing Maple Products* by R. D. Bell, Cornell Agricultural Economics Department. A.E. 1016. 1955.

the bacteria become active. One of the visible signs of sour sap is a mucous formation in the buckets. Microorganisms in the sap cause formation of invert sugar and darker and lower grade sirup. For this reason, it may be wise to clean and scald the buckets and spiles after mucous formation. Some producers ream out the old tap hole to make one or two more runs. Little is known of how worthwhile are the practices of cleaning equipment and reaming in late season.

True buddy sap comes during bud-swelling and means the end of the season. The sap has a very unpleasant odor. This buddy sap, due to physiological changes in the tree as it starts its spring growth, has nothing to do with the microorganisms of maple sap. Many producers who specialize in only high-quality sirup pull their buckets and spiles considerably before the buds swell, though some "buddy" sirup is drummed.

Drying of tap holes

Recent research shows that the tap hole drys up because of the action of microorganisms. These infect the spile and the tap hole. As weather conditions favor the growth of microorganisms, they penetrate into the cells of the wood and effectively seal off the holes. Reaming alone may do little or no good since the bacteria reinfect tap holes sometimes within 24 hours. Many producers have pulled and washed spiles and buckets in chlorine compounds which has helped to keep bacteria count down. Others have flushed out tap holes with these compounds with good results, though as yet this practice has not been thoroughly tested.

EQUIPMENT

A list of the more important equipment of a complete sugar-making outfit, with a few notes on the size of the operation for which each is adapted, follows:

- Tapping bits, 7/16 inch in diameter (at least 1/4 dozen)
- Reamer, 1/2 inch in diameter (optional)
- Brace, breast-drill, or power tapping machine
- Claw hammer for removing spiles
- Hand axe
- Spiles or spouts
- Buckets, 14- to 16-quart capacity
- Bucket covers
- Gathering pails (in pairs 16- to 20-quart capacity)
- Gathering tank 3- to 10-barrel capacity
- Plastic pipe (if used)
- Storage tanks from 8- to 50-barrel capacity (poured concrete tanks useful)
- Sap house
- Evaporator and arch
- Hydrometers (sap and sirup)
- Dial or target thermometers
- Standard maple-sirup grading set
- Large flat felt or 4 "boot" type felt filters and filter box. Also rayon filter paper for sap
- Settling can from 15- to 100-gallon capacity (optional)
- Bucket washer
- Sugaring-off arch and pan (optional)
- Skimmer
- Tin or glass containers for packaging sirup
- Molds and boxes for maple candies and maple cream

A partial list of manufacturers of maple sirup-making equipment, several of whom have furnished catalogs which have been helpful in the preparation of this bulletin, may be obtained from the Department of Conservation, New York State College of Agriculture, Ithaca, New York.

Such equipment described in the following pages costs from $2.00 to $3.00 for each bucket to be hung. This is on the basis of new materials but does not include the cost of erecting an evaporator house. Most New York farms have three-fourths of this sugaring investment in the sap house, buckets, and evaporator.

Hand-tapping bit

If a brace is used, a coarse threaded screw type bit with oval lips is recommended. If a breast-drill is used, the same type of bit is needed but with fine threads. Several users of the breast-drill prefer a fast-cutting type without any screw thread. This type is often called the *bobbin bit* or *wood drill* and is preferred for use in the tapping machine. A 7/16-inch diameter is standard. Two men can tap and hang from 500 to 600 buckets per day.

Reamer

Under present conditions and with labor costs high, it is questionable whether reaming pays. The reamer does not remove enough of the bacteria-infected wood to make additional flows pay for the labor. Other methods such as washing spiles and buckets in chlorine or dairy compounds help.

Power-tapping machines

Power has come to the sugar bush to enable the operators to tap more trees faster. In fact, one man with the power-tapping machine keeps as many as three to five other persons busy driving spiles, hanging from 2000 to 3000 buckets, and placing covers in a day.

There are two general kinds of tapping machines. One is powered by electricity from a storage battery carried in a pack frame; the other is powered by a gasoline motor. In the one powered by electricity the bit is driven by a starting motor carried by a sling over the shoulder. One well-charged battery will tap from 600 to 700 trees.

Figure 11. Light-weight, direct-drive, gasoline-powered tapper.

Several commercial gasoline motors are available. Some producers use the direct drive where the motor and bit are carried by a sling in front of the operator (figure 11); others carry the motor on a pack frame and use a flexible shaft to bring the power to the tapping bit. Several operators of bushes have used adaptations on one-man chain saws to power tapping bits. With all of these machines, a 2- to 4-inch hole can be bored in a few seconds.

Spiles or spouts

Most all of the steel spiles now in use are coated with tin or zinc to prevent corrosion. Some light aluminum alloy spiles have been sold but are not yet in general use. Two general types are on the market. One is made of coated malleable iron. Horizontal or vertical flanges on the part of the spile driven into the tree hold the bucket in place and yet close off a minimum number of openings in the conducting vessels cut by the bit. These spiles are made both with and without a hook for hanging the bucket. With the hookless spile, the bucket is supported by the spile itself.

The other is of sheet steel rolled to form an elongated funnel and coated to prevent rust. The small end is not entirely closed. A long downward-curving underlip leads the sap to the bucket without allowing backflow on the underside of the spout. A slip ring with hook is provided to hold the bucket though many operators enlarge the hole in the bucket, drive the spile through the hole, and empty the bucket by spinning the bucket on the spile.

Buckets

In many sugar bushes the wooden buckets of olden days are still used. Those that have been cared for and coated on the inside with sap-bucket paint to insure cleanliness are most useful.

Metal buckets are most commonly used and are zinc coated to prevent rust, though some are of aluminum. In most sugar bushes the 14- to 16-quart sizes are common, though larger sizes are used in some areas. For ease in nesting and separating, it is important that the buckets are humped near the top.

In some areas, operators have expanded production beyond what can be cared for in the usual day-to-day gathering. To prevent loss and overflow, large utility cans with covers have been used. One operator, with eighteen years of experience with 8- to 10-gallon cans, taps an isolated bush before the "first run," hangs large cans with covers, and collects three to four times per season. His quality has remained high and his production in gallons of sirup per man day of labor is high. With large cans he has no overflow loss. Other operators use 5-gallon cans on free-

Figure 12. Ten gallon can for sap gathering from "big runners" or remote trees. Note: corrugated can unharmed by solid freezing.

running trees or in back-lot bushes. Usually such buckets, hung very early in the season in remote parts of the bush are gathered less frequently than normal. Experience shows that freezing damage is nil on corrugated containers (figure 12).

Recently a plastic sap bag (figure 13) has been used. These are light and occupy little storage space. Ultra violet light or sunlight passes through the plastic and kills bacteria, which ordinarily multiply rapidly, sometimes enabling the producer to make good sirup until buddy sap flows. The bag is emptied by spinning on the spile. Present models have two disadvantages. The top is narrow and consequently in cold weather only small amounts of ice may be removed. Furthermore, the bags hold only 10 to 12 quarts and the overflow loss may be great unless the bags are placed where they may be gathered frequently. Bags have occasionally been damaged by high winds or rough-barked trees and by squirrels puncturing them to get the sweet water. Present models may well be used on smaller, smooth-barked trees, and sap should be collected daily to prevent freezing.

Bucket covers

Bucket covers are essential in the efficient production of high-quality sirup and sugar. Covers are of many types but all effectively keep out sticks, insects, and dirt; prevent rain, snow, or ice from dropping

Figure 13. The plastic bag has advantages and disadvantages.

in; and keep the sap cool and sweet by shading it from the warming rays of the sun. Plastic bags have attached covers.

Gathering pails

Gathering pails need to be larger than sap buckets. The usual size is from 18 to 20 quarts and they are made of galvanized iron or more recently aluminum. Most pails are made broader at the base to prevent tipping and spilling. The new aluminum pails are made with short coupled handles and a recessed base to facilitate dumping. Two buckets are used by each gatherer.

Gathering tank

Gathering tanks are made in many sizes, depending on the power used, the distance of the haul, and the number of buckets to be served. For horse-drawn tanks, the 3-, 4-, and 5-barrel sizes are most common; on down-hill runs and for roadside use with tractor or truck power, 10-barrel tanks save man hours of labor. The tanks may be mounted on low skids, stone boats, wheeled trailers, tractor drawbar, or pick-up truck (figure 14). They are equipped with a splash cover, a top strainer for removal of bark, leaves, and other debris and an outlet pipe.

It is important to supplement the built-in metal strainer with several thicknesses of cheesecloth, closely

Figure 14. The tractor has replaced the horse for sap gathering on many farms. Sap being dumped from gathering tank into underground storage tank.

woven burlap, or cotton sacking, and to filter it as it is emptied into the storage tank.

Pine lines

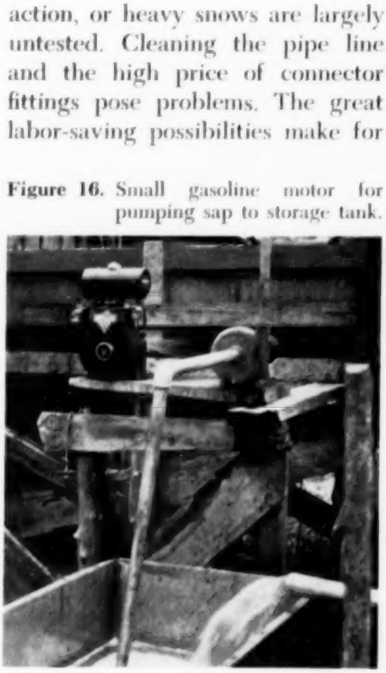
Recently the fortunate bush operator whose sap house is downhill from the sugar bush has been able to save hundreds of hours of labor by using gravity to convey sap to the storage tank. The most primitive of these "pipe lines" is a gutter or eaves trough set on uprights through the bush. Sap buckets are dumped into the trough anywhere along the line. The method is likely to add water and debris to the sap. A better type is to use several dumping stations along the gathering road. These tanks are covered to keep out water and debris and are connected to a metal pipe line graded to the storage tank. Care must be taken to see that the line is built without sags which will break from freezing. Plastic pipe instead of metal pipe has been used re-

Figure 15. Plastic pipe to carry sap from dumping station in sugar bush to the road or saphouse.

cently. This plastic pipe has the advantage that freezing and thawing will not damage it. A 400-foot coil of plastic pipe may be carried by one man to the site (figure 15).

The latest development is the possible use of plastic pipe all the way to the tap hole, thus eliminating the need for buckets or spiles and greatly decreasing the gathering time. This has been little tested, but deserves trial in hard-to-reach places where the trees are close together. One-fourth- and three-eights-inch pipe line has been used thus far. A piece of ⅜-inch pipe can be bevelled in a pencil sharpener and pushed into a $\frac{5}{16}$-inch tap hole. One-fourth-inch line fits snugly inside the three-eighths-inch pipe. The effects of sap freezing in the line, molestation by deer or other animals, possible leakage, microbial action, or heavy snows are largely untested. Cleaning the pipe line and the high price of connector fittings pose problems. The great labor-saving possibilities make for

Figure 16. Small gasoline motor for pumping sap to storage tank.



high interest in experimenting with plastic pipe lines.

Since gathering and transporting amounts to about 40 percent of the labor of an average sugaring operation, greater use should be made of pipe lines where topography permits. Some operators use suction pumps to move sap from dumping vats to tanks and even from the bucket to gathering tanks (figure 16).

Storage tanks

Metal storage tanks are made with a capacity of 8, 10, 15, 20, or more barrels. The size is determined by the size of evaporator used and the number of buckets hung. The usual requirement is 1 barrel of storage space for every 50 buckets hung. These tanks take care of the usual flow of sap if the evaporator is kept going. Tanks should be adequately supported, on the cold side of the saphouse, above the evaporator, and covered with a tight roof. The tank should not be in the saphouse because the heat causes the rapid multiplication of bacteria and consequent fermentation of sap. Ideally, the storage should be on the north or east side above the level of the evaporator but below the road so that the sap from the gathering tank or pipeline may flow directly into the storage tank and on to the evaporator.

Often sap flows are greater than can be handled or the time available for evaporation is limited and sap must be held over for short periods. Many bush operators have used insulated glass-lined milk tanks, iron tanks sunk into the ground, or reinforced concrete tanks built underground to hold sap. Provision must be made for access into these tanks and for water to scrub and flush them out between runs. Where these conditions prevail, excellent results are obtained with a saving of labor.

Where gravity cannot be used to move sap in and out of storage, small electric or gasoline motors attached to pumps lift the sap to the right level.

Saphouse

The saphouse should be near the sugar bush, yet near enough to the other farm buildings to use electricity and running water. A saphouse near the road, can be used also as a sales room. With the use of pipe lines or with horse-drawn tanks that collect the sap in the bush and later transfer it to tractors or trucks, an increasing number of producers are bringing the saphouse out of the woods.

Producers spend many hours over the evaporator, often working late into the night. In spite of such long hours during harsh weather, many producers seem to take pride in having the saphouse as rough a shack as will just cover the evaporator. For efficient evaporation and protection of the equipment from the weather during its idle months,

however, the house should be well built, with tight sides, and on an adequate foundation. Creosoted poles may save construction costs. The floor should be of concrete where soil conditions allow and water should be available to flush the floor clean several times during the season. Light from both windows and electricity should be available. There should be plenty of working space around the evaporator, with work benches and adequate space for filter cans and bottle or can-filling equipment. Adjustment of height of evaporator and work benches makes the job easier (figure 17).

A permanent stack, or chimney, of brick, cinder, or concrete blocks is more economical than a metal one since it does not rust nor does it have to be put up and dismantled yearly. The stack should extend well above the building to insure good draft but not so high as to create so much draft that the fire roars and wastes fuel. Most users report that permanent stacks are shorter than metal ones. Manufacturers of equipment state that the metal stack should be twice as tall as the evaporator is long.

Overhead, in the roof peak, extending the full length of the evaporator and as wide as the evaporator, must be a ventilator with either side capable of being opened from below. Driving winds may be kept out by closing the windward

Figure 17. New sap house under construction. Features include creosoted pole construction, concrete floor, open woodshed at one end, and adjustable vent opening over evaporator.

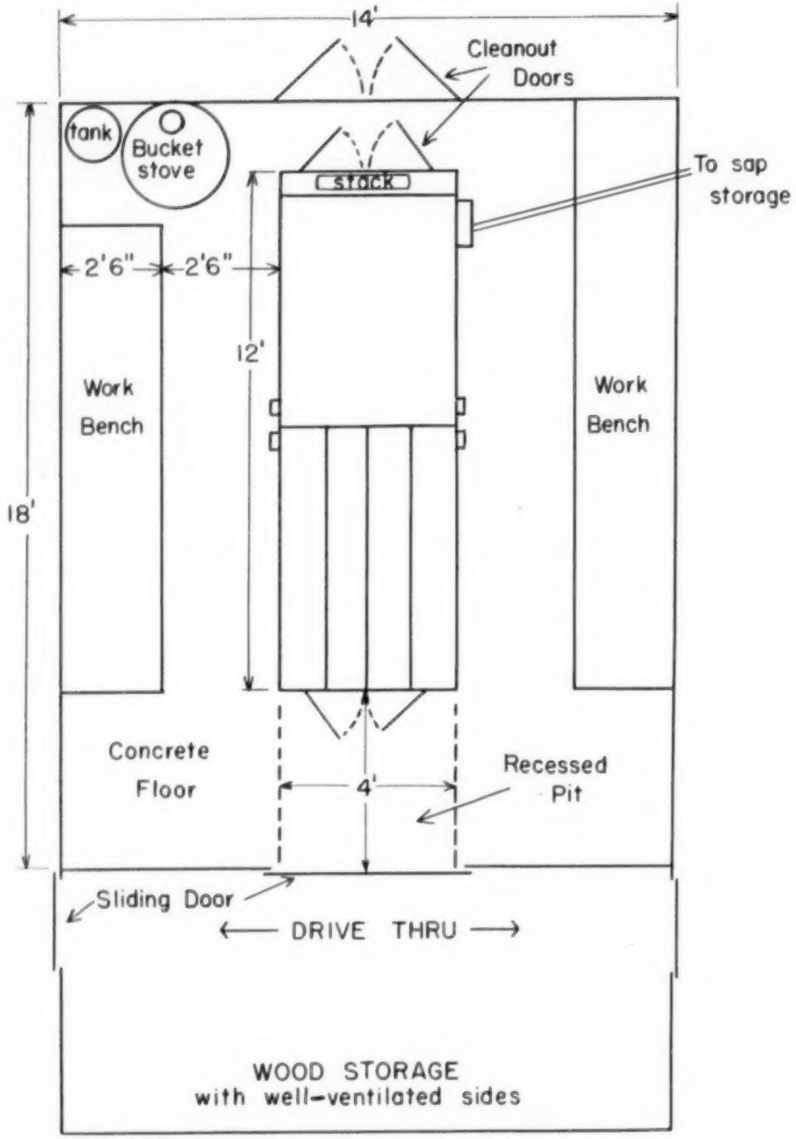


Figure 18. Sap house plans

side. Cross drafts cool the sap and lengthen the boiling time, while good ventilation hastens evaporation. If steam is to be driven out, an equal volume of cool air must be admitted to replace it. This may be admitted through vents near the ground level in the sides of the saphouse. In old saphouses the cracks between boards took care of this. Hoods from the roof vent to about head height over the evaporator also help to suck out steam and should be used where steam hangs in the house.

Adjoining the saphouse should be adequate space to store a standard cord (4 feet by 4 feet by 8 feet) of fuel wood for every 60 to 75 buckets hung. The space should be roofed but need not be sided. Wood should be stored under cover for at least nine months to be dry enough for a hot, fast fire (figure 18).

Evaporators

History says the earliest evaporators were bark vessels into which the Indians dropped hot stones. These gave way to open kettles, which in turn were supplanted by flat pans. Each is slow and, under most conditions, produces an inferior product because the long boiling of the half concentrated sap carmelizes the sirup and darkens it. This carmelization flavor often completely overshadows the true maple flavor. Thus, many oldtimers truthfully say that modern sirup is different from most sirups they knew as boys. From this, too, arises the request for "first-run" sirup, for under the flat-pan technique the pans are clean, the sugar is unscorched, and the sirup is more truly maple.

Modern evaporators, still undergoing change, are designed to reduce sap to sirup with the least possible loss of time or waste of fuel. Corrugations of flues in the bottom of the pan give more boiling surface; cleverly arranged, narrow, partitions conduct the sap from one end of the evaporator to the other in a gradually thickening flow. Fireboxes and flues have been improved and are being adapted for modern oil fuels. At present, 30 percent of the labor of making sirup is due to the "boiling down" process (table 3).

Nearly all evaporators now used in the State are of English tin plate. Galvanized iron does not stand up well when subjected to high temperatures, particularly at folds or bends. Copper, aluminum, and stainless steel are too expensive.

In estimating the evaporating capacity of the modern flue-type evaporator, one uses the following information: 1 square foot of corrugated bottom is capable of evaporating sap of average concentration (2 percent) at the rate of 2 gallons per hour when proper fuel, draft, and ventilating conditions are met. Thus an evaporator 3 by 8 feet, with 24 square feet of heating area, evaporates from 40 to 50 gallons of sap per hour.

Table 4. Relation of Size of Evaporator to Number of Buckets Hung

Size of evaporator			Capacity based on 10 hours of continuous boiling			Size of evaporator			Capacity based on 10 hours of continuous boiling		
Inches		*Feet*	*Number of buckets*			*Inches*		*Feet*	*Number of buckets*		
30	by	8	50	to	200	40	by	16	500	to	600
36	by	10	200	to	300	48	by	12	400	to	550
36	by	12	300	to	400	48	by	14	500	to	600
40	by	8	150	to	300	48	by	16	550	to	700
40	by	10	200	to	400	60	by	14	600	to	800
40	by	12	300	to	500	60	by	16	800	to	1000
40	by	14	400	to	600	72	by	16	1000	to	1500

Recently many operators have felt that labor at the evaporator was more expensive than the investment in a big machine; consequently, many have obtained larger evaporators and put more sap through in a shorter time. This has also tended to increase quality because the sap is boiled down from the storage tank faster. For example, a producer hanging 600 buckets normally would require an evaporator 4 feet wide by 16 feet long (table 4). In order, however, to boil the sap faster, he has obtained one 5 by 16 feet. In larger operations where 2000 to 10,000 buckets are used, it has been the trend to add more feet of sap pans to the evaporator rather than to add more complete evaporators. Research has proved that there is little change in color or flavor in sap from 2 percent to 40 percent sugar concentration, yet above that point the change is rapid and decidedly to the low grades if boiled too long. To take advantage of this, the larger operators have used an auxiliary evaporator to handle sap as low as 15 to 20 percent sugar concentration and then run that sap into the sirup pan in the second evaporator where it rapidly concentrated to standard sirup. The auxiliary evaporator is only casually cared for while the main evaporator is kept at optimum boiling conditions.

Other evaporator equipment

Other equipment is essential for the manufacture of good sirup. A thermometer is most useful to check the sap for standard density while in the evaporator. The boiling point of standard sirup (a 65.5 percent sugar solution weighing 11 pounds per gallon of 231 cubic inches) is 7° F. above the boiling point of water. Though commonly 212° F. is considered the boiling point of water, this varies with the elevation above sea level and the barometric pressure at the time. Hence thermometers must be calibrated several times a day to allow for barometric change. Two general

types of thermometers allow for calibration: One is the target thermometer that has been used inside the pan and, when steam is rising, is difficult to read. A newer, very accurate, dial type is easier for the operator to read because it is mounted through the pan and is easily read outside the steam. A typical installation is shown in figure 19.

Hydrometers may be used, preferably the Brix scale which reads density direct. When cold sirup (68° F.) reads 65.5° Brix, the solution is of that percent sugar. Slender-necked hydrometers read much more accurately than the thick-necked ones. Hydrometers are however less accurate than thermometers when testing hot sirup.

Other evaporator equipment would include a strainer for skimming off impurities and a dipper to dip sap into the pan in case the level gets too low.

Filters are essential if the product is to be of retail quality. In most large operations, the flat felt squares used on a flat hardware cloth support enable rapid filtering. Rayon prefilters supported above the felts on a hardware cloth support, also hasten filtering and prolong the period between washing the felts. "Boot" or "hat" type felts may also be used but are slower and require larger investment in felts to filter the same quantity of sirup. Filter or settling cans should be arranged so that hot sirup (180° F. or more) may be packaged direct from the filter to save labor.

Figure 19. Modern boiling. Note filter, stand, and dial thermometer mounted in sirup pan next to outlet.

Standard permanent grading sets are available from the Department of Agriculture and Markets at Albany. With this grading set, the sirup made may easily be classified at the official New York grades.

MAKING SIRUP

Preliminary preparations

Cleanliness and speed are two requisites to the manufacture of high-grade sirup. These must be applied to the entire operation from gathering to canning or bottling if a light-colored, true-maple-flavored product is to be produced.

It is desirable to boil the sap to sirup within 24 hours after the sap flow.

Before the season, every utensil of the sugaring outfit, from spiles to evaporator pan and filter tanks, should be scrubbed and scalded. Many operators sterilize spiles, buckets, and gathering tanks with chlorine compounds commonly used in the milk house. Roads should be broken through the bush along trails laid out to keep distances to a minimum. Containers for sirup and sirup products, of glass or tin, should be ordered long before tapping so they will be at hand when the season opens.

Fuel

The evaporator previously described is designed for fuel that is burned in the fire box of the arch with heat applied to the bottom of the evaporator pans. Wood is the most common fuel though some use a combination of wood and soft coal, used crankcase oil, and fuel oil. Fuel oil is becoming common where wood, labor, or a combination of the two are difficult to obtain.

Wood

Wood is the most practical fuel to use in New York because transportation is eliminated. No better use can be made of thinnings from the young bush, or from cull or weed trees in the mature bush, than for next season's fuel supply. By working at this at odd times during the sugar season or earlier, the cost is insignificant and the benefits are great.

For every 60 to 80 buckets hung, one standard cord of well-seasoned wood should be available at the start of the season. Green or wet wood is unsatisfactory. During the average season, a standard cord of seasoned wood makes from 20 to 30 gallons of sirup in the modern flue type of evaporator. When flat pans or green or wet wood is used to evaporate low-grade sap, more wood is needed.

Crankcase oil

Holes are drilled in both sides of the arch just below the pans and a ½-inch pipe, with small holes bored at intervals along the lower side, is placed in position and connected with a drum of filtered oil set to provide gravity feed. Dripping oil from the holes onto the wood fire maintains a steady heat. The holes may become carbonized so it is well to have several sections of pipe as replacements. Recently, commercial oil burners that use old crankcase oil have proved successful, and fuel of this type is low in cost.

Fuel-oil burners

Commercial oil burners have recently been installed in many sugar houses. These burners are most useful where large amounts of sap must be handled rapidly, where

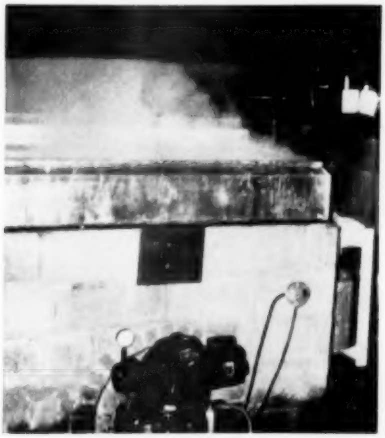


Figure 20. With oil burners properly installed, sirup-making is easier and a more uniform sirup is usually made. Note the hood above the evaporator to direct the steam out of the sap house.

labor is unavailable or too expensive to cut fuel wood, or where rapid control of temperature is needed. The usual installation is made only where electricity is available in the saphouse and where oil trucks have access to the saphouse. Installations of these oil burners is not always simple. The placing of the units, the arrangements of the fire brick within the arch, and the location of the draw-off valve for finished sirup must be considered.[2] Oil-fired evaporators may not boil sap quite so vigorously as does wood, but many operators favor them because of the constant, uniform boiling and the excellent control of heat. Oil is not cheaper than wood; the usual installation produces 1 gallon of sirup with 2½ to 4 gallons of fuel, depending on the sweetness of sap (figure 20).

[2] A pamphlet on oil-burner installation is available from Eastern Utilization Research Branch, U. S. Department of Agriculture, and may be obtained by request from them at Philadelphia 18, Pennsylvania.

Steam

Steam, an ideal heat because there is no danger of burning the sirup, is a rapid way to produce high-quality sirup. If a stationary boiler of adequate size can be obtained, the cost of pans and evaporator is low. The partly evaporated sap in the large, deep pans is drawn off into a smaller, deep, finishing-off pan and brought to standard density. This assures a uniform product.

One operator in Allegany County uses a 25-horsepower boiler and galvanized tanks (10 feet long, 3 feet wide, and 2 feet deep) with several copper steam pipes in the bottom for evaporating pans. He boils the sap nearly to sirup and finishes it off in a deep stainless-steel finishing pan. In his bush he cares for 1600 buckets adequately and evaporates the sirup at 120 pounds of steam pressure.

Starting the evaporator

Like the spouts and buckets, the evaporator must be thoroughly clean before operation is started.

This may be done by boiling water in the evaporator thoroughly and scrubbing the evaporator. Heavily tinned or copper evaporators may be cleaned by filling them with a weak solution of hydrochloric (muriatic) acid and allowing it to stand for an hour or two. (Galvanized iron is badly corroded by this acid and should not be treated in this way.) The weak acid partially dissolves the sediment so that it may be scrubbed off while running water through the pan. The pan must be well rinsed before filling it with sap. Less fuel is needed when the soot has been removed from underneath the pans.

Before starting the fire, the intake from the storage tank must be in adjustment and flowing freely. The siphons must be working and the bottoms of the pans must be covered with sap from 1 to 2 inches deep. More depth than this prolongs the period of concentration and makes the product dark; too shallow a depth of sap results in scorched sap, damaged pans, and a difficult cleaning job. As the sap boils, that in the sirup end of the pan should be dipped back to the inflow end of the sirup pan until sirup of the desired density is flowing into the outlet. In the meantime, the scum, which constantly rises should be removed with a skimmer. This may be saved as a basis for vinegar. Scum should never be thrown carelessly about the place. Every effort should be made to keep the house and the surroundings clean and free from foul smells.

At the end of each day the evaporator should be cooled and held partly full of sap or water overnight. This can be done by flooding the pan with sap while the fire is hot, taking care that the pans do not boil dry. The surface of the sap must be skimmed before leaving it overnight. In the morning the bottom of the pan will be covered with a deposit. Unless this is scraped and the sap is stirred before building the fire, the heat will cause the deposit to stick to the bottom of the evaporator and a dark, poor-flavored sirup will result. Part of the sediment may be skimmed as it rises during boiling and the remainder will run out with the first few gallons of sirup. Some evaporators are constructed so that the flow is reversed daily; this helps to clean the pans. Each morning the evaporator will have to be started with care to keep the pan from burning dry and to insure a steady flow from the sap intake to the outlet where the finished sirup is drawn off. To produce a clean bright sirup, the evaporator should be cleaned every two or three days, depending upon the quantity of sediment. It cannot be emphasized too strongly that care must be taken to keep the pans clean, for dirty pans are the cause for much low-grade sirup.

Boiling sirup

During the evaporation of the sap to sirup, the point at which standard sirup is reached can be measured by either a thermometer or a hydrometer.

In using the thermometer to determine the temperature of the boiling point of the sirup, one must read carefully and accurately the temperature at which water (sap) boils and add 7 degrees to this, because the amount of sugar in standard sirup raises the boiling point of the sirup 7 degrees above the boiling point of water (sap). It is necessary to test the temperature of boiling water (sap) at least twice a day in the saphouse. The boiling point of water is constantly changing due to variations in barometric pressure. Care must be exercised that the point at which the temperature is taken in the evaporator is the one where the sap is boiling very rapidly. The target and dial thermometers described on page 35 make it easy to adjust temperatures for these changes in pressure which are caused by variations in atmospheric conditions and by differences in elevation.

For testing boiling sirup, the hydrometer is more troublesome than a thermometer. It is necessary to draw from the evaporator a cylinder full of sirup and to float the hydrometer in it. If the drawn-off sirup has not cooled more than 5 degrees, the hydrometer reading for 11 pound sirup is 59° Brix or 31.5° Baumé.

Standard density sirup contains 65.5 percent solids as sugar. Sirup of less than 65 percent density is likely to ferment and sour, while that which contains more than 67 percent may crystalize or granulate. For that reason sirup weighing between 11 and 11¼ pounds to the gallon is the most satisfactory.

Filtering the sirup

Heavy felt filters (page 35) have been largely adopted as the standard method of getting rid of malate of lime, sometimes called "nitre" or sugar sand, which is present in all maple sirup. One of these filters is placed in the mouth of the settling can and the hot sirup is run through directly from the evaporator. The amount of sirup that can be run through one of these filters depends upon the amount of sugar sand in the sirup. Some operators have to change the boot type with every 3 to 4 gallons filtered; others filter as much as 10 gallons of sirup without a change. It is always best to have three or four filters on hand. Large flat felts filter many times these amounts before a change is needed. New felt filters should be thoroughly boiled in water to remove any unpleasant odor or taste. The same surface of the filter must always be placed up. Before the filter is placed in the settling can, it must be thoroughly soaked in boiling sap, if it is to function efficiently. Sirup at low temperatures will not run through a filter at all. Since

saphouses are often drafty, the filtering can should be protected as much as possible from quick cooling. A cover fitted over the top of the can helps to retain the heat necessary to do a quick job of filtering.

When filters become clogged with sugar sand, they are removed, the boot type turned inside out, and washed thoroughly in a bucket of boiling water or sap. When thoroughly cleansed, the filter should be turned back to its normal position and the excess water squeezed out. For best results, an old-fashioned hand wringer is recommended. *Wringing by hand tends to strain the fibers of the filter and shortens its period of usefulness.*

The use of a prefilter of rayon pressed cloth or some similar material supported over the felt filter takes care of heavy sludge, so the filters do not require frequent changes and washings.

Canning

Many producers still can their sirup cold, because they depend on settling sirup over-night to get rid of "sugar sand." Sirup canned cold will undoubtedly keep if the container is properly filled and the caps are screwed on securely. In cold canning, the container should not be filled to the top, otherwise there is no room for expansion should the sirup be stored in a warm place. In tin cans, this expansion is often taken care of by bulging of the sides of the can, but with glass there is no possibility of such bulging and the glass bursts. *Never should one can sirup cold for shipment or for sale in stores.*

Canning sirup while it is hot is the logical sequence to the use of felt filters. A tap placed in the bottom of the filtering can allows this canning to be done while the temperature is still above 160° F., assuring a sterile package. The container is filled to the brim and the cap is screwed on tightly. Contraction due to cooling leaves a partial vacuum at the top of the container. The cans should be set apart so they will cool rapidly and not cause further coloration of sirup.

Testing cold sirup

The hydrometer is the best instrument for measuring the density of cold sirup. In the past it has been the practice to use a Baumé hydrometer which measures densities on an arbitrary scale called *degrees Baumé*. The best hydrometer now being used employs the Brix scale, which measures the density in terms of the percentage of sugar present and tells the amount of sugar present in direct readings. This is the recommended hydrometer. Both hydrometers are made to be used at 68° F. If the sirup tested is at some other temperature, either above or below 68° F., a correction must be made by adding to or subtracting from the observed reading (the point at which the hydrometer

floats in the sirup). This is done by determining the number of degrees of difference between 68° and the observed temperature at which the sirup is tested, multiplying this difference by 0.047 for Brix (or 0.024 for Baumé) and adding the result to the hydrometer reading if the observed temperature is above 68° F. The result is subtracted if the observed temperature is below 68° F.

Examples:

The temperature of sirup is 45° F. and the hydrometer reads 67° Brix.

$68° - 45° = 23°$

$23° \times 0.047 = 1.08°$ Brix

$67 - 1.08 = 65.92°$ Brix

(subtract since temperature is below 68° F.)

The temperature of sirup is 80° F. and the hydrometer reads 65.5° Brix.

$80° - 68° = 12°$

$12 \times 0.047 = 0.56°$ Brix

$65.50 + 0.56 = 66.06°$ Brix

(add since temperature is above 68° F.)

Table 5. Temperature Corrections for Hydrometer Readings

Temperature	°Brix	°Baumé	Temperature	°Brix	°Baumé
40°F. subtracted from reading	1.3	0.7	65°F. subtracted from reading	0.1	0.1
45°F. subtracted from reading	1.1	0.6	68°F. no change	0.0	0.0
50°F. subtracted from reading	0.8	0.4	70°F. add to reading	0.1	0.1
55°F. subtracted from reading	0.6	0.3	75°F. add to reading	0.3	0.2
60°F. subtracted from reading	0.4	0.2	80°F. add to reading	0.6	0.3

Table 6. Schedule for Brix and Baume Hydrometer Readings

Weight per gallon	Hydrometer scale	Temperature in degrees Fahrenheit					
		40°	50°	60°	68°	70°	80°
		Hydrometer readings					
Pounds							
11	Brix	66.8	66.3	65.8	65.5	65.4	64.9
11¼	Brix	71.6	71.2	70.7	70.3	70.2	69.8
11	Baumé	36.0	35.8	35.5	35.3	35.2	35.1
11¼	Baumé	38.4	38.1	37.9	37.7	37.7	37.4

Jack wax, soft sugar, maple cream

Delicious confections are provided when the temperature of sirup is raised from 18 to 20 degrees above the boiling point of water (figure 21). If the sirup is poured at once over snow or cracked ice, a chewy sweet called *Jack wax* is the result. With pickles and a fork for twirling up a layer of wax, the makings of a jack-wax party are at hand.

If the sirup is stirred for a few minutes after it is removed from the stove, it soon crystallizes and can be poured into molds or containers. Each degree higher the sirup is allowed to boil, the stiffer becomes the soft sugar.

If the sirup is poured into a flat dish, allowed to cool rapidly to room temperature (70° F.), and then stirred continuously with a spoon for from 15 to 20 minutes, a delicious confection known as *maple cream* is the result. Many producers have devised mechanical mixers so that large batches of maple cream can be made at one time. Packaged in attractive waxed-paper containers, this product commands the highest market prices. Demand for this product exceeds supply.

Maple sugar

If the sirup is allowed to boil until the thermometer registers from 28° to 30° above the boiling point of water, the product will be hard, or cake, sugar. This is stirred immediately on removal from the stove just as is the soft sugar to start crystal formation, and poured into molds, either in pound blocks or fancy shapes, such as maple leafs, rabbits, and the like.

Maple candies

Maple cream forms the base for the manufacture of a wide variety of dainty confections. If one has attractive molds available, it is well worth while to make pure maple cream or fudge in different shapes and to sell it in dainty packages. Nuts may also be added, either chopped or in halves, on the top of the molds. Many maple-sugar producers have found it profitable to cater to the tourist trade by direct sales at roadside booths or to build a mail-order business through advertising. While sirup, as well as sugar, is often sold, this business

Figure 21. The kitchen range is used to make delicious maple confections. Note the target thermometer.

rests essentially on maple sugar in the form of high-grade confectionary.

In making these confections from maple sirup, the target thermometer is as valuable as it is in the sap house in testing standard sirup. As soon as the sirup is put on the stove to boil, this target thermometer is calibrated by placing it in a pan of boiling water.

Packages for sirup and sugar

Only the producers' ingenuity limits the type of package he chooses for his maple products. Lithographed or plain tins, glass jars or bottles, wooden or tin pails, paper cartons or confectionary boxes are all used.

The producer who prepares sirup for local trade or home use usually packs in the large, family-size package—the gallon tin. For more distant markets, for sale at the roadside stand, or in stores, smaller packages of tin or glass have increased the gross sales during recent years. Studies of marketing techniques show that these smaller packages have more buyer appeal. Pints, quarts, half gallons, and intermediate sizes all have their place depending on market demand (figure 22).

The principal advantage of tin is its ease of packing for shipment and ready availability. Glass is in demand both by the buyer and the producer because it permits the buyer to see the product and the producer to use a distinctive, in-

Figure 22. Attractive labels, small containers, and variety of products help sales.

dividual label. Tin enables unscrupulous producers to pack inferior products. Tin also cannot be held over from year to year due to rust.

To assure vacuum-sealed packages, all tin now comes with inner seals which must be punched out to open. Glass containers may likewise be sealed by using plastic sealers which insure vacuum seal and make more attractive packages.

Colorful, attractive labels for glass, tin, sugar jars, or paper cream boxes may now be obtained with the individual's name and address prominently displayed.

Glass glue or paste may be obtained from manufacturers of labels or the following recipe may be used:

One-half ounce of silicate of soda (water glass), 1 ounce of cornstarch, and 1½ pints of cold water. Add the starch and the silicate to the water and stir the mixture until the whole is smooth, then place the vessel in a double boiler and heat it until the starch is gelatinized. This paste should be made often as it soon loses its sticking properties.

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